AD-A079 131   DAVID W TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CE--ETC   F/G 20/4
FLOW ORIENTATION NEAR THE HULL OF DD 963 IN THE VICINITY OF THE--ETC(U)
DEC 79   W G DAY

UNCLASSIFIED   DTNSRDC/SPD-0311-44   NL

1 OF 1
AD A079131

END
DATE
FILMED
2 -80
DDC

DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Md. 20084

DTNSRDC/SPD-0311-44

FLOW ORIENTATION NEAR THE HULL OF DD 963
IN THE VICINITY OF THE ELECTROMAGNETIC SPEED LOG
SWORD AS DETERMINED BY EXPERIMENTS WITH MODEL 5359-1

BY

W. G. DAY, JR.

FLOW ORIENTATION NEAR THE HULL OF DD 963 IN THE VICINITY OF THE ELECTROMAGNETIC SPEED LOG SWORD AS DETERMINED BY EXPERIMENTS WITH MODEL 5359-1

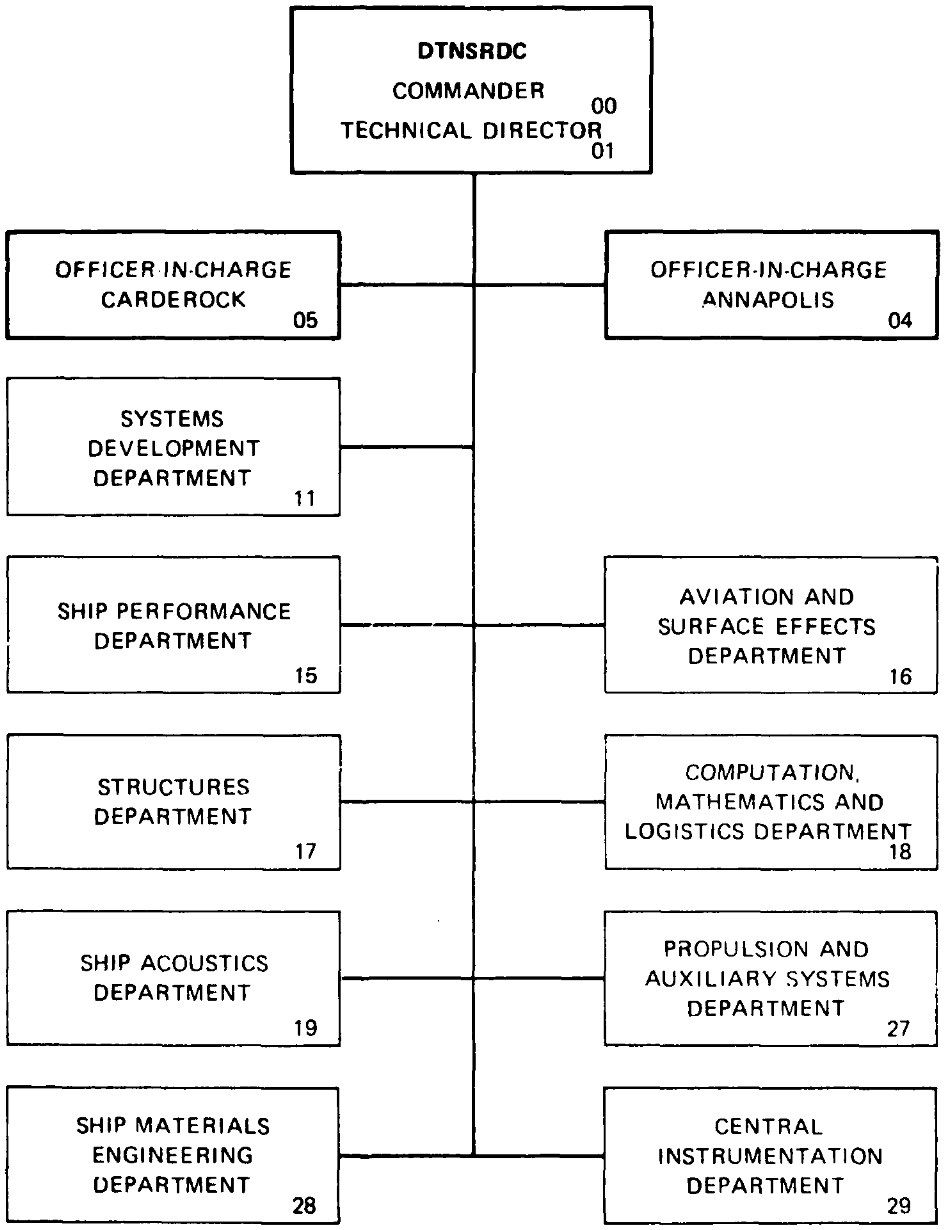
APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

SHIP PERFORMANCE DEPARTMENT REPORT

DECEMBER 1979

DTNSRDC/SPD-0311-44

MAJOR DTNSRDC ORGANIZATIONAL COMPONENTS



UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

14 **1. REPORT NUMBER**
DTNSRDC/SPD-0311-44

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

6 **4. TITLE (and Subtitle)**
Flow Orientation Near the Hull of DD 963 in the Vicinity of the Electromagnetic Speed Log Sword as Determined by Experiments with Model 5359-1

9 **5. TYPE OF REPORT & PERIOD COVERED**
final rept.

6. PERFORMING ORG. REPORT NUMBER

10 **7. AUTHOR(s)**
W. G. Day, Jr

8. CONTRACT OR GRANT NUMBER(s)
12 13

9. PERFORMING ORGANIZATION NAME AND ADDRESS
David W. Taylor Naval Ship R&D Center
Bethesda, Md. 20084

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
NAVSEA WR 91549
DTNSRDC Work Unit 1524-694

11. CONTROLLING OFFICE NAME AND ADDRESS
Naval Sea Systems Command (SEA 3213) 379
Washington, D. C. 20362

11 **12. REPORT DATE**
DEC [redacted] 79

13. NUMBER OF PAGES
8

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Speed Log
Flow Orientation
DD 963

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Flow angles were measured near the hull of a 1 to 24.824 scale model of the DD 963 in a towing tank to determine whether the electromagnetic speed log sword was operating at high angles of attack. The results showed a small angle of flow in the vicinity of the speed log sword, approximately equal to 3 degrees with respect to the centerline of the hull.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

389 694

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

Flow angles were measured near the hull of a 1 to 24.824 scale model of the DD 963 in a towing tank to determine whether the electromagnetic speed log sword was operating at high angles of attack. The results showed a small angle of flow in the vicinity of the speed log sword, approximately equal to 3 degrees with respect to the centerline of the hull.

ADMINISTRATIVE INFORMATION

This project was carried out under Naval Sea Systems Command (NAVSEA 3213) Work Request No. 91549 and the David W. Taylor Naval Ship R&D Center (DTNSRDC) Work Unit No. 1-1524-694.

INTRODUCTION

The Naval Sea Systems Command (NAVSEA) has learned that ships of the DD 963 Class have experienced failures with the electromagnetic speed logs. In one case the complete rodmeter (sword) was carried away. Such a failure may be due to the sword's vibration caused by periodic eddy shedding or due to large forces generated if the sword experiences a high angle of attack relative to the incoming flow. In order to more clearly identify the cause of the failure, information is needed to indicate the angle of flow near the hull of the DD 963 in the area of the electromagnetic speed log sword.

NAVSEA requested the David W. Taylor Naval Ship R&D Center (DTNSRDC) to perform a model experiment which would determine the flow orientation while using an existing model of DD 963 and available instrumentation. The recommendation of DTNSRDC that a two-hole pitot tube be used to determine the flow angle, as opposed to acid trace and flow flags as originally indicated, was agreed upon by the NAVSEA project manager.

This report documents the experiment performed at the Center and includes a description of the model and instrumentation used. The results of this experiment are presented in the form of a flow angle relative to the hull centerline at various positions along the span of the speed log sword. The experiment indicated a small angle of flow relative to the hull centerline for the majority of these positions.

MODEL EXPERIMENTAL CONDITIONS

DTNSRDC Model 5359 was built of molded fiberglass to a scale ratio of 24.824 to represent the DD 963 Class. Alternative afterbodies were also built in order to investigate various propulsion arrangements, but the forebody is identical to that of the DD 963 and includes the bow sonar dome. The flow angle on the hull was measured during one of the experiments in which an alternative afterbody had been fitted to the model for propulsion investigations, with a resulting change in model number to 5359-1. The alternative afterbody should have no effect on flow measurement at the location of the speed log in the forebody.

The model was ballasted to a displacement corresponding to 7820 tons (7945 m tons) in an even keel condition while at rest, and then was towed at a speed corresponding to 32 knots (16.46 m/s) while free to attain a running sinkage and trim. The model was locked into that attitude while performing measurements with the pitot tube during subsequent runs at the same speed.

A two-hole spherical pitot tube was used to measure flow angles. These two holes were 40 degrees apart on a meridian of a 3/8-inch (9.5 mm) sphere, which was attached to a shaft perpendicular to the plane of the two holes. An indicator with a quadrant was attached to the shaft in order to show the bisector of the angle between the two holes. This shaft was installed in the model with a sleeve assembly allowing movement along the line of the shaft.

The pitot tube was installed on the port side of the model at a position corresponding to the location of the electromagnetic speed log sword. In ship scale dimensions this location was 8.03 feet (2.45 m) aft of station 5 or 2.58 feet (0.79 m) aft of frame 138, and penetrated the hull at an angle of 42 degrees from a vertical line 10.54 feet (3.21 m) outboard of the centerline of the hull. The pitot tube was extended from a point near the hull surface to a point approximately 60 inches (152 cm), full scale, from the hull surface. This range was adequate to define flow angles over the entire span of the electromagnetic speed log sword which is approximately 36 inches (91 cm) in length. A schematic drawing illustrating section and plan views of the speed log sword is shown in Figure 1.

The total pressure at each of the two holes of the pitot tube went to either side of a differential pressure gage. When the two pressures were equal, a null reading was indicated by the differential pressure gage. The spherical tube was rotated about the shaft axis until the null reading was indicated. At that point the angle shown by the bisector indicator was read from the quadrant, this angle being assumed to be a measure of the flow angle at the pitot tube. The precision of this flow angle measurement system is plus or minus one degree with a repeatability of data plus or minus two degrees. This system is considered to be more reliable than the flow flag technique used in the past.

PRESENTATION OF RESULTS

The angles which were measured using the two-hole pitot tube at various distances from the model hull surface are shown in Figure 2. The distances are presented in full-scale inches (or centimeters) along the axis of the electromagnetic speed log sword. The angle of flow is shown with respect to a line in a plane perpendicular to the axis of the sword and parallel to the intersection of the centerplane and load waterline (LWL) of the hull. Angles are considered to be positive when the trailing (after) edge of the sword is rotated toward the centerline of the ship (i.e. in a downward direction).

The data in Figure 2 indicate the flow angle in the speed log sword region to be approximately 3 degrees, trailing edge toward the centerline of the hull. Approaching the hull surface, this angle increases only slightly to 7 degrees. The values near the model hull may provide less reliability due to interference with the flow pattern caused by the close proximity of the spherical pitot tube to the hull surface. Therefore, no data were taken closer than 5 inches (12.7 cm) full scale to the hull.

An additional reason for placing less emphasis on the data near the hull is found in the difference between ship and model Reynolds numbers and therefore boundary layer thickness. Calculations made using Schlichting's formulation[1], as presented in Appendix A, indicate that the boundary layer thickness at the position of the speed log sword would approximate 11 inches (28 cm) full scale and 1.1 inches (2.8 cm) model scale. This model-scale dimension of 1.1 inches (2.8 cm) corresponds to a ship-scale dimension of 27.8 inches (70.6 cm). Based on this calculation, the angle of flow is considered to be valid only for larger distances away from the hull.

As a check on the magnitude of the flow angle measured with the two-hole pitot tube, a diagonal through the speed log sword position was developed on the ship lines plan. At the position of the sword this "bilge-diagonal" makes an angle of 2.5 degrees with a line parallel to the

---

[1] Schlicting, H., "Boundary Layer Theory," 6th edition, McGraw-Hill, New York (1968).

centerline of the hull. The flow angle of 3 degrees, measured by the two-hole pitot tube, indicates that the flow in the area of the speed log is following a diagonal, as expected.

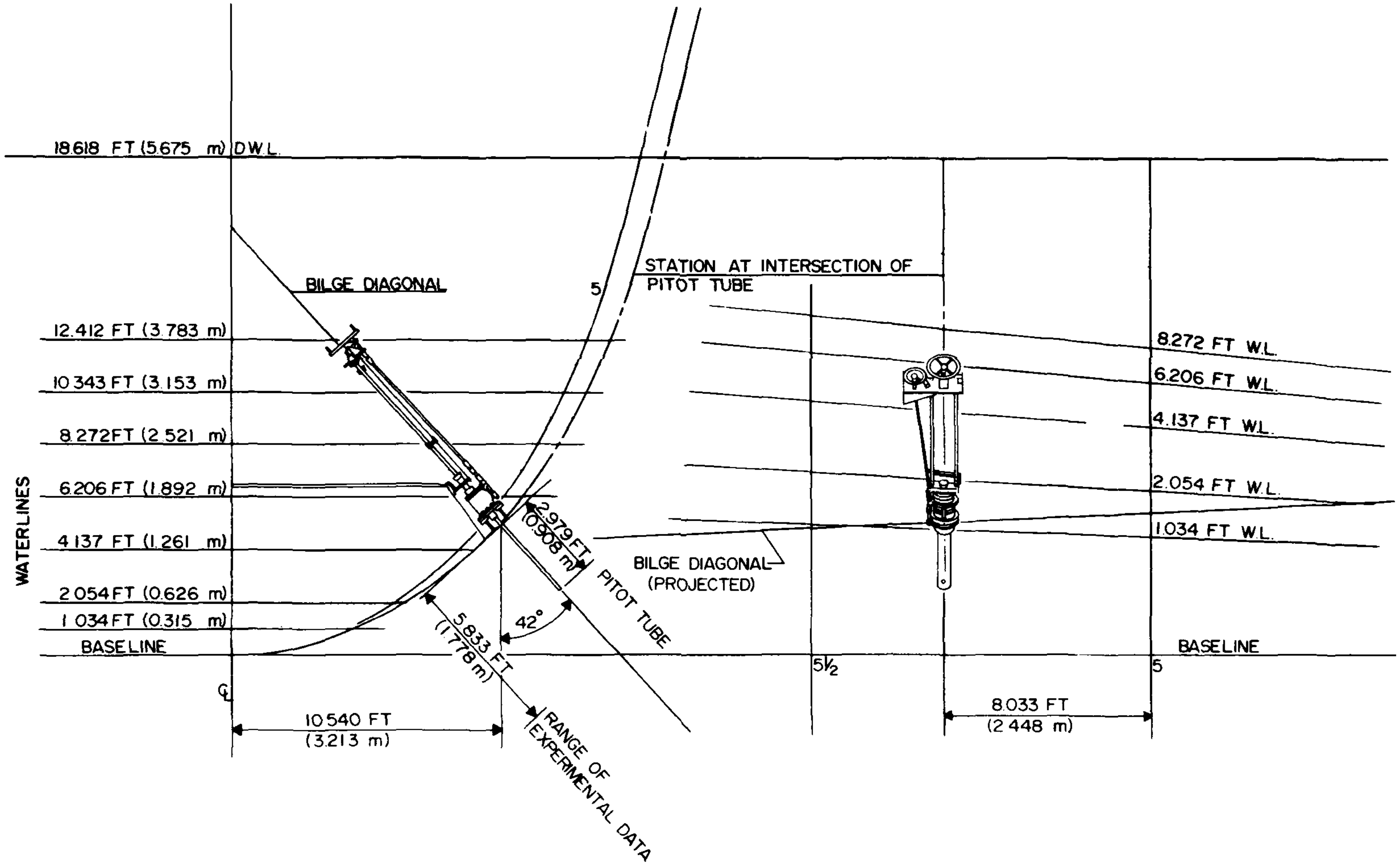
CONCLUSIONS

The flow angle in the position of the electromagnetic speed log on the DD 963 model is approximately equal to 3 degrees. Slightly higher angles are measured closer to the hull surface. These angles are considered to be reasonable, based on development of a diagonal in the area of the speed log sword. The magnitudes of these angles do not appear to be sufficient to cause difficulties such as failure of the sword.

Vibration of the speed log sword may have been the cause of the failure if periodic eddy shedding from the sword occurs at some often-used ship speed. If the periodic eddy shedding were to occur with a frequency which coincides closely with a fundamental vibration mode of the sword, the resulting vibration could lead to failure. It is recommended that further analysis of the speed log sword failure include more detailed investigation of the eddy shedding problem, perhaps even using actual full-scale hardware in the towing tank at actual ship speeds.

FIGURE 1

ELECTROMAGNETIC SPEED LOG SWORD LOCATION ON DD 963



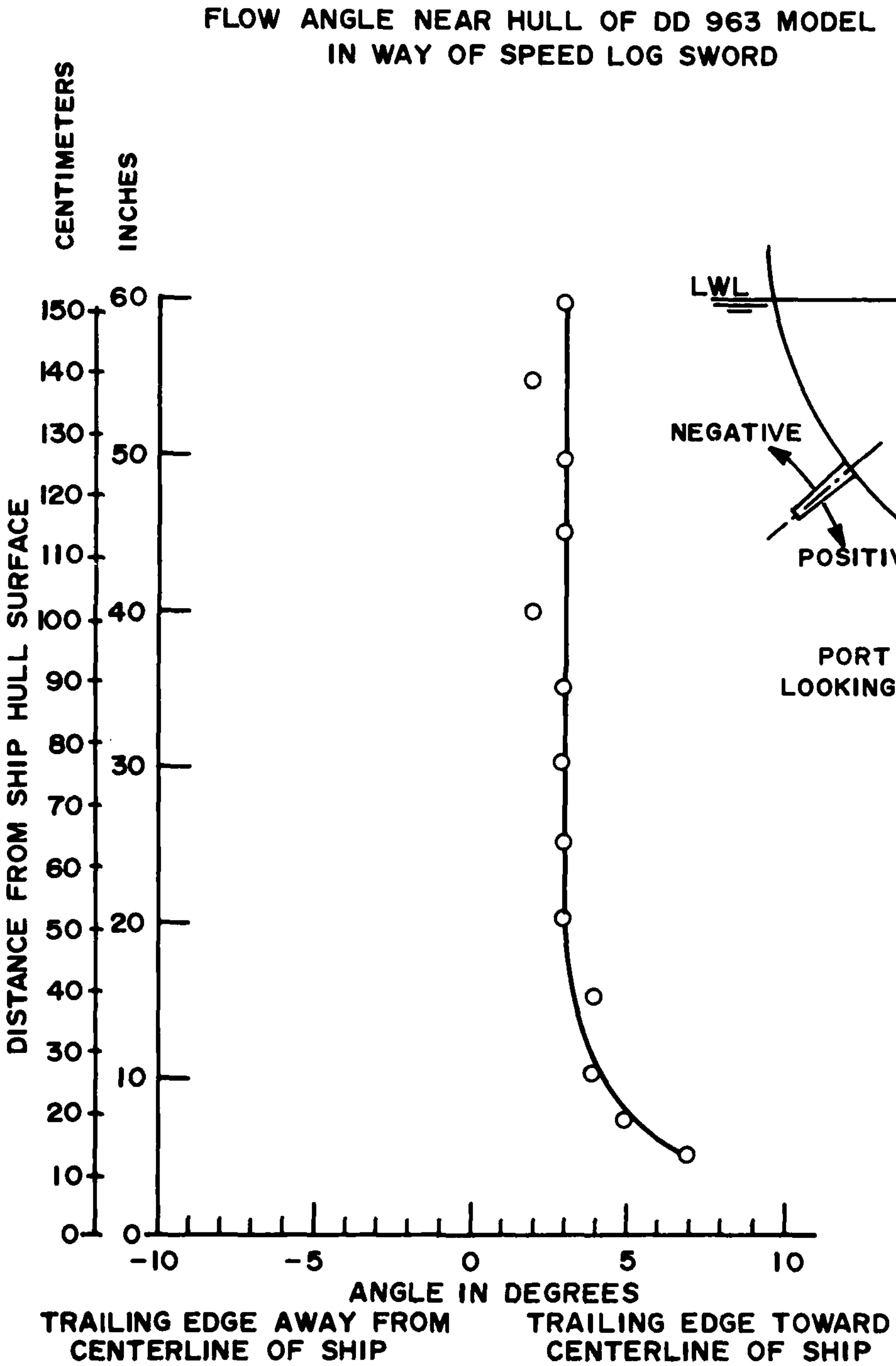

FLOW ANGLE NEAR HULL OF DD 963 MODEL
IN WAY OF SPEED LOG SWORD
CENTIMETERS
INCHES
DISTANCE FROM SHIP HULL SURFACE
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
60
50
40
30
20
10
0
-10
-5
0
5
10
ANGLE IN DEGREES
TRAILING EDGE AWAY FROM CENTERLINE OF SHIP
TRAILING EDGE TOWARD CENTERLINE OF SHIP
LWL
NEGATIVE
POSITIVE
PORT SIDE LOOKING FORWARD
℄

FIGURE 2

APPENDIX A - Calculation of Boundary Layer Thickness

Reference: Schlicting, H., "Boundary Layer Theory," 6th edition, McGraw-Hill, New York (1968)

Equation 21.8, p. 599 expresses the thickness of a turbulent boundary layer as follows:

$$\delta\ (x) = 0.37\ x \left(\frac{V_\infty\ x}{\nu}\right)^{-1/5},$$

where

$\delta\ (x)$ = thickness of boundary layer at x

x = distance from leading edge

V_∞ = free-stream velocity

and ν = kinematic viscosity

In this particular case, we may do the following calculations:

	Ship	Model
V_∞	= 32 knots = 54.01 feet per second	6.422 knots = 10.84 feet per second
ν	= 1.2817×10^{-5} ft^2/sec	1.08×10^{-5} ft^2/sec
x	= 140.6 feet aft of F.P.	5.664 ft aft of F.P.
$R_n(x)$	= 5.925×10^8	5.685×10^6
$R_n(x)^{-0.2}$	= 1.760×10^{-2}	4.457×10^{-2}
δ/x	= 0.00651	0.01649
δ	= 10.99 inches	1.12 inches
	$\delta_m * \lambda$ =	27.8 inches

DTNSRDC ISSUES THREE TYPES OF REPORTS

1. DTNSRDC REPORTS, A FORMAL SERIES, CONTAIN INFORMATION OF PERMANENT TECHNICAL VALUE. THEY CARRY A CONSECUTIVE NUMERICAL IDENTIFICATION REGARDLESS OF THEIR CLASSIFICATION OR THE ORIGINATING DEPARTMENT.

2. DEPARTMENTAL REPORTS, A SEMIFORMAL SERIES, CONTAIN INFORMATION OF A PRELIMINARY, TEMPORARY, OR PROPRIETARY NATURE OR OF LIMITED INTEREST OR SIGNIFICANCE. THEY CARRY A DEPARTMENTAL ALPHANUMERICAL IDENTIFICATION.

3. TECHNICAL MEMORANDA, AN INFORMAL SERIES, CONTAIN TECHNICAL DOCUMENTATION OF LIMITED USE AND INTEREST. THEY ARE PRIMARILY WORKING PAPERS INTENDED FOR INTERNAL USE. THEY CARRY AN IDENTIFYING NUMBER WHICH INDICATES THEIR TYPE AND THE NUMERICAL CODE OF THE ORIGINATING DEPARTMENT. ANY DISTRIBUTION OUTSIDE DTNSRDC MUST BE APPROVED BY THE HEAD OF THE ORIGINATING DEPARTMENT ON A CASE-BY-CASE BASIS.